THE BIG TREES AS A CLIMATIC MEASURE

By ERNST ANTEVS

Annual growth rings of certain big trees in various parts of the world have been used as a climatic yardstick, whereby the rainfall record has been pushed back to the very beginnings of recorded history. The nature of the record is of such character, however, as to introduce grave doubts as to the accuracy of the interpretation that has been put upon it by various students. Meteorologists will therefore welcome the contribution that Doctor Antevs has made particularly since it bears directly upon phases of the interpretation of the records which have not hitherto been sufficiently clarified. The work doubtless grew out of the conference on weather periodicities held under the auspices of the Carnegie Institution of Washington in 1923, in which the author participated. In his introduction the setting of the study is described as follows:[1]

* * * In 1911, Professor Ellsworth Huntington, of Yale University, began his measurements on the big tree (Sequoia washingtoniana) in the Sierra Nevada in California, which, since corrections for nonclimatic factors had been applied, enabled him to construct a climatic curve reaching 3,000 years back. The results obtained by Doctor Douglas and Doctor Huntington are of great and many-sided importance and have increased our knowledge of climatic periodicity particularly.

The studies had reached the point where the need of detailed analyses of the factors influencing growth, of easily applied methods of correction, etc., made themselves felt, and therefore this restudy of Doctor Huntington's sequoia material has been carried out under the auspices of the Carnegie Institution of Washington at the request of its president Dr. John C. Merriam. The study has been made possible by Doctor Huntington's generosity in placing all his original material and annotations at the writer's disposal. During the course of the investigation at Yale, Doctor Huntington has aided in word and deed. * * *

Space does not permit detailed reference to the treatment of the material and illustrations; only the outcome of the examination are given, the latter in the author's own words.

On the preceding pages has been shown how the varying rate of growth at different age stages, effects of individual and local nature, flaring, etc., have been eliminated as accurately as possible from the growth curves. The remaining variations of the curves may be due largely to changes in climate and weather, though it must not be thought that every little fluctuation necessarily has climatologic significance. Importance should be attached only to large features.

As stated on this page, separate curves, not published, were calculated from measurements of those parts of trees that are less than 1,301 years old and from those parts that are 1,301 to 2,100 years old. The curves of parts under 1,301 years show fluctuations lacking in the other curves; besides, in these curves the maxima that also occur in the curves of parts 1,301 to 2,100 years old are more pronounced, commence earlier, and last longer.

"DRY" CURVE AND "MOIST" CURVE

The finally corrected curves based upon all trees growing in dry and wet sites, respectively (curves 1 and 2, fig. 7), show better agreement with each other, the greater the material upon which they are based. Therefore the less exact correspondence in the earlier parts of the curves may in the first case be due to insufficient material. After 800 A. D. the correspondence is indeed remarkable. The curves are about equally pronounced. Marked maxima occur in both curves in the beginning of the tenth and eleventh centuries, during the fourteenth century, and from 1550 to 1750. A secondary maximum is common to both in the thirteenth century. Minima are common to both curves in the latter parts of the ninth, tenth, twelfth, thirteenth, fifteenth, and eighteenth centuries. The curves also show noteworthy differences, as the somewhat delayed appearance of the maxima in the dry curve, indicating slower reaction of the trees living in dry sites. Other differences are secondary maxima in the dry curve about 1130 and 1810 and in the wet curve 1080 to 1090, and 1890. Between 1 A. D. and 800 A. D. the curves do not show very good agreement, but present a great number of relatively small independent fluctuations. In common are a minimum during the third century, a secondary maximum about 370 and 380, as well as minima about 100, 500, 560 to 570, and 650 to 660.

The fluctuations in the earlier parts of the curves being very marked because of the scanty material, smoothed curves, calculated after the formula $\frac{a+2b+3c+2d+e}{9}$ and the resultant figure used for c, have been plotted above the actual growth curves. These smoothed curves show fairly good agreement from 700 to somewhat after 500 B. C., but after that they have rather independent courses. So have the unsmoothed curves from 200 B. C. to 1 A. D.

ALL FINALLY CORRECTED CURVES

A comparison of all finally corrected curves—that is, curves based upon trees in dry situations (curve 1, fig. 7), in moist situations (curve 2), in dry and moist situations (curve 3), in all kinds of situations (curve 4), and Huntington's (1914), fig. 38, and table G, p. 323, column F) curve (without the Caspian factor) based upon trees in all kinds of situations and obtained after a different method of correction (curve 5)—reveals the remarkable fact that they all agree in those parts that are computed from a very large quantity of material. Thus, the correspondence is particularly good, partly even detailed, since 800 A. D. All of the curves show maxima in the beginning of the tenth and eleventh centuries, during the fourteenth century, and since about 1550. They have minima in the latter parts of the tenth and twelfth centuries and about 1300 and 1500. During the eighteenth century the dry curve (curve 1) falls lower than the rest, and from 1770 to 1880 the wet curve (curve 2) is rather low. Since 1850 the dry curve remains low, while curves 2, 4, and 5 rise.

This writer has not extended the curves beyond 1000 B. C., since only a few trees reach farther back and elimination of the factors of non-climatic nature therefore hardly can be made. The smoothed curves (curves 2, 3, and 4), from 1000 to 700 B. C., where largely computed from the same material, show good agreement with each other, but hardly any correspondence to Huntington's curve (curve 5), which has partly reversed course. From 700 to 500 B. C. all curves, including that of Huntington, agree rather well. Between 500 and 200 B. C., as mentioned, the maxima and minima in trees living in dry and moist situations occur at different times, giving all the curves different courses. Huntington's curve follows our curve 3 most closely. Not too much weight should be laid upon these earlier parts, for the material is too small for elimination of nonclimatic features, and satisfactory correction of them can not be made. To get around this last-mentioned difficulty, this writer has excluded the earliest parts of the trees, and this fact probably is the reason for some of the discrepancies between the writer's curves and that calculated by Huntington.

From about 200 B. C. to 800 A. D. all the curves present a great number of small fluctuations, and show neither marked similarities nor discrepancies. From 200 to 100 B. C., curves 1 and 5, however, are considerably low; and from 150 to 130 B. C. curve 4 also is very low.

The agreement between those parts of the curves that are calculated from a very large quantity of material is particularly significant, since different methods of correction and different age stages of the trees have been used to construct them. The agreements, consequently, are real, of external origin and almost certainly of climatic nature. This fact, together with conditions set forth on pages 125 to 132, signifies that the growth of the big tree, allowance made for eccentricity, effects of casualties, etc., is essentially determined by a combination of factors, and that the rôle played by each factor is subordinate and varying. The dependence of tree growth on the entire constellation of environmental conditions, not on individual conditions, is also emphasized by MacDougal (1924, p. 81) and Shreve (1924, p. 116).

The chief climatic factors influencing tree growth, as discussed on pages 125 to 132, appear to be precipitation, temperature, and sun radiation. The relative rôle of each factor is dependent on the time of its influence, upon other factors, upon internal conditions in the tree, upon earlier conditions in general, etc. Thus, growth can primarily follow now this, now that, factor. No direct study of the relationship has ever been made, so that not even the general laws are known. In the case of the big tree the importance of the individual factors is much more difficult to estimate, as data of temperature are entirely wanting. However, it appears to be certain that the sequoia curves do not specially record precipitation. High parts in the curves might directly or indirectly be connected with periods of heavy rainfall and low parts with scanty rainfall, because of the relationship between the different climatic factors as influenced by the activity of the sun, so that trees in moist and dry sites might be favored or checked contemporaneously

[1] Ernst Antevs, Quaternary climates, Publication No. 352 of the Carnegie Institution of Washington, pp. 115-153.

by different factors, but it can not be concluded that all high and low parts were connected with rainfall and drought. In this connection it is noteworthy that the tree-growth maximum during the fourteenth century coincides with an exceptional spottedness of the sun (Huntington and Visher, 1922, p. 109) and with the climatic stress, of which there are abundant historical records in the Old World, and which particularly expressed itself in unusually cold winters, cold rainy summers, and devastating storms.

Accordingly, before satisfactory interpretation of the sequoia curves and conclusions from them regarding the climate of the past can be made, it is necessary to have data on temperature, better knowledge of the relation between precipitation and growth of sequoia trees in dry situations, and general knowledge of the rôle for growth played by the radiation of the sun.

Besides being of climatological interest, the sequoia curve is of importance as eventually affording a possibility to extend the Swedish postglacial geochronology up to the present time. This chronology (not yet published), worked out by Ragnar Lidén (1911) in the valley of the River Ångermanälven (63° N.), is based upon annually laminated silty clays deposited in fiords of the Gulf of Bothnia ever since the disappearance of the last ice-sheet. The annual deposit consists of two thin layers, in texture and in color somewhat different, one of which may be essentially deposited in connection with the flood of the rivers during the melting of the snow in spring. By the upheaval of land, amounting to about 920 feet (280 meters), the clays have been gradually raised above sea-level and trenched by the rivers. Those from the last hundreds of years are not yet accessible, and Lidén has had to estimate the length of time that has elapsed since the formation of the youngest measured varve or annual layer.

This gap in the record might be bridged by help of the sequoia curve, for it seems likely that it will show a certain correspondence to the sedimentation curve in Norrland. The climatic stress during the fourteenth century, so distinctly recorded in the sequoia curve, is probably also recorded in the clay deposition. If this prove to be the case, and also other marked fluctuations in the tree curve are found in the clay curve, a connection may be made with high degree of probability, and the length of the postglacial time, which amounts to 8,500 to 9,000 years, exactly determined.

—*A. J. H.*

TORNADO IN SOUTHEASTERN ALABAMA

Mr. P. H. Smyth, meteorologist in charge of the Montgomery, Ala., Weather Bureau station, sends an account of a tornado which occurred in southeastern Alabama on October 25, 1925. This tornado was notable for being one of the most destructive storms of its kind that has occurred in southeastern Alabama, and also as being only the second tornado of record for October within the State.

It was clearly attendant upon the passage of a well-defined wind-shift line in the trough of low pressure connected with a depression the center of which passed northeastward over the Ohio Valley during the night of the 24th–25th, the tornado apparently having been first observed about 2:00 a. m.

The path was 75 to 80 miles long, beginning about 50 miles north of the Alabama-Florida line and extending ENE. to within about 10 miles of the Alabama-Georgia line. It was some 400 yards wide at its widest part.

The number of lives lost was reported to be 18; many persons were injured; property losses were estimated at a quarter of a million dollars.—*B. M. V.*

METEOROLOGICAL SUMMARY FOR SOUTHERN SOUTH AMERICA, OCTOBER, 1925

[Reported by Señor J. B. Navarrete, El Salto Observatory, Santiago, Chile. Translated by B. M. V.]

In the month of October the period of atmospheric disturbances, starting in September, began to decline; rainfall diminished over the whole of the southern part of the continent.

Between the first and the third an important atmospheric depression lay over the southern region, causing bad weather with violent winds and rains between Coquimbo and Magellanes; the most important amounts of precipitation were 18 mm. at Valparaiso, 16 mm. at Talca, 19 mm. at Traiguen, 13 mm. at Valdivia and 14 mm. at Punta Arenas.

On the 4th, in the afternoon, an important V-shaped depression caused electrical storms accompanied by violent squalls and hail in the interior of Aconcagua, Santiago, and O'Higgins Provinces.

Between the 5th and the 10th a large anticyclonic area persisted, characterized by general good weather, with winds prevailingly southeast and rising temperature.

Between the 11th and the 13th a moderate depression caused variable weather and drizzling rain in the central zone.

From the 14th to the 22d a large anticyclonic area lay over the central part of the continent, causing steady atmospheric conditions. General fine weather was the rule during the period, with heavy south winds between Chiloe and Arauco and high temperatures over the whole central zone of Chile.

During the 23d and the 24th a depression of some intensity lay over the southern area, causing rains between Valdivia and Magellanes; at Valdivia 11 mm. fell.

Between the 26th and the 28th another cyclonic depression, more important than the previous one, affected the whole southern region of the continent; on this occasion rain and wind storms occurred from Valdivia southward. On the island of Huafo the wind velocity reached 25 m/s. (56 m/h.).

During the last days of the month atmospheric pressure rose over the southern part of the continent, reestablishing the anticyclonic régime, with general fine weather and rise of temperature.

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C. Fitzhugh Talman, Meteorologist in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

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